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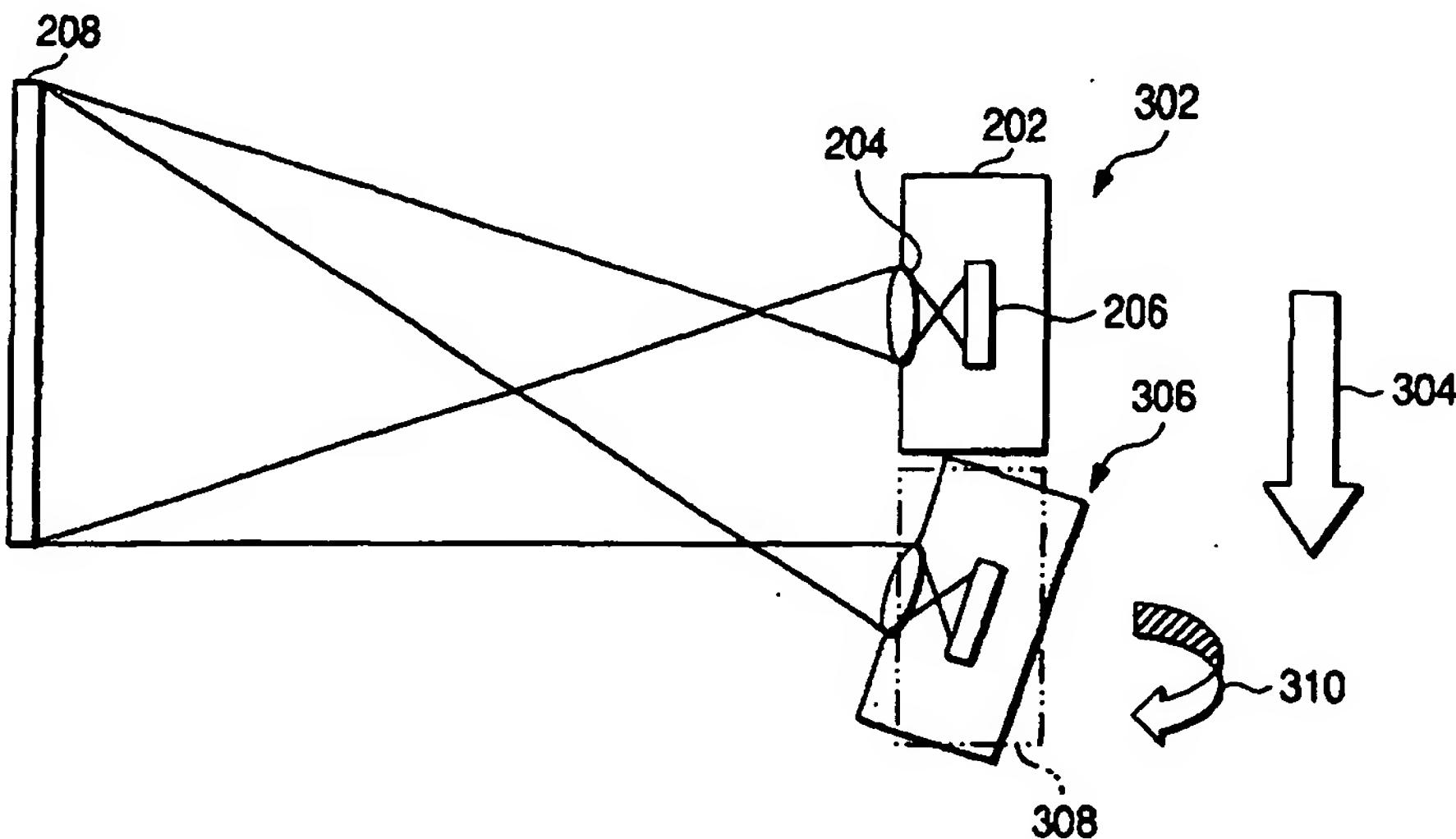
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(54) An image stabiliser for a microcamera module of a handheld device and method for stabilising a microcamera module of a hand-held device

(57) A method and a hand-held device for stabilizing an image captured by an optical lens of a micro camera integral with the hand-held device, which may, for example, be a mobile phone. Motion sensors sense motion of the device and are used to cause movement of the micro camera to substantially compensate for the

sensed movement so as to maintain a steady, focused image to be displayed by a display on the hand-held device or elsewhere, such as a remote display. The micro camera is moved by one or more motion actuators which move the camera in a horizontal plane substantially perpendicular to an axis of the lens of the camera and/or move the camera so as to pivot the lens axis.

Fig.3



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Description**BACKGROUND OF THE INVENTION****Field of the Invention**

[0001] The present invention relates to image stabilization, and, in particular, is directed to a method and hand held device for stabilizing an image.

Description of the Related Art

[0002] Hand-held devices such as mobile or hand-held terminals provide enormous flexibility over traditional wired telephone handsets. These hand-held devices enable the communication of data, voice and/or video at locations other than a residence, office or pay-phone. To enhance such communication of information, many hand-held devices have included special components and features. For example, hand-held devices include micro camera modules to process and provide video and imagery.

[0003] One problem in providing video and imagery is to stabilize a previously focused image if the hand-held device moves slightly. Current image stabilization methods use a normal camera having several lenses or prisms. However, micro camera modules are generally small in size, e.g., they may be only a few millimeters, and, because of their size, are generally restricted to having a single lens. As such, current image stabilization mechanisms that require multiple lenses or prisms are not appropriate for use with hand-held devices having micro camera modules. There is thus a need in the art to provide image stabilization for hand-held devices with micro camera modules.

SUMMARY OF THE INVENTION

[0004] The present invention is directed to a method and a hand-held device for stabilizing an image captured by a hand held device. The hand-held device has an optical lens assembly and an image sensor which capture a focused image of an object. Movement of the hand-held device is sensed by motion sensors in the hand-held device. In response to the sensed movement of the hand-held device, the micro camera module or merely the lens and image sensor are moved to compensate for the sensed movement to maintain the previously defined and focused image. The movement of the micro camera module or merely the lens and image sensor may be a pivoting/tilting or a translation.

[0005] The image stabilization device and method of the present invention has a variety of uses. In particular, for use as a videophone and for taking of video images, the hand-held device can provide a video image substantially without motion, vibration, blur, and the like generally caused by unintended movements of the hand-held device. The hand-held device of the present

invention can also take sharp, static pictures at a slow shutter speed because image stabilization compensates for the effects of hand movement associated with operation of the shutter of the camera.

5 [0006] Other objects and features of the present invention will become apparent from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are intended solely for purposes of illustration and not as a definition of the limits of the invention, for which reference should be made to the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

15 [0007] In the drawings, wherein like reference numerals delineate similar elements throughout the several views:

20 FIG. 1 depicts a front view of an exemplary hand-held device;
 FIG. 2 depicts a top view of the hand-held device of FIG. 1 depicting a micro camera module;
 FIG. 3 depicts a stabilization of an image in accordance to the present invention;
25 FIG. 4 depicts a block diagram of one embodiment of the hand-held device;
 FIG. 5 depicts a block diagram of another embodiment of the hand-held device;
30 FIG. 6A depicts a side view of a first implementation of the embodiment of FIG. 4;
 FIG. 6B depicts a top view of the implementation of FIG. 6A;
 FIG. 7A depicts a side view of a second implementation of the embodiment of FIG. 4;
35 FIG. 7B depicts a top view of the implementation of FIG. 7A;
 FIG. 8A depicts a side view of a first implementation of the embodiment of FIG. 5;
40 FIG. 8B depicts a top view of the implementation of FIG. 8A;
 FIG. 9A depicts a side view of a second implementation of embodiment of FIG. 5;
45 FIG. 9B depicts a top view of the implementation of FIG. 9A; and
 FIG. 10 depicts a flow chart of a method for stabilizing an image in accordance with the present invention.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

[0008] FIG. 1 depicts a front view of an exemplary hand-held device 100 which may be used with the present invention. The particular hand held device 100 shown is a mobile phone. The hand-held device 100 is configured to transmit information in the form of text, voice, video sound and the like. The hand-held device

100 comprises an outer case 102, a display 104, an antenna 106, a speaker 108, a microphone 110, and a keyboard 112. The outer case 102 defines the external structure of the hand-held device 100. The display 104 is configured to display various forms of textual and video information. For example, the display 104 may display a list of telephone numbers or an image of an object.

[0009] The antenna 106 enables the transmission and reception of information to and from the hand-held device 100. The speaker 108 transmits audio in the form of an audible signal to a user of the hand-held device 100. The microphone 110 receives audio from the user of the hand-held device 100. The keyboard 112 comprises one or more buttons or switches to facilitate the operation of the hand-held device 100. For example, the keyboard 112 comprises buttons to power up the hand-held device 100, to activate specific features of the hand-held device 102, and to dial telephone numbers.

[0010] FIG. 2 depicts a top view of the hand-held device 100 comprising a micro camera module 202 to focus and capture an object 208 and to provide an image for the captured object 208 on the display 104. The micro camera module 202 is designed to be sufficiently small to fit into the hand held device 110 and generally contains only a single lens 204, although more than one lens may be used. The lens 204 is used to focus an object 208 onto an image sensor 206 in the micro camera module 202. The image sensor 206 identifies the object as captured through the lens 204. Different embodiments of the hand-held device 100 are further described with respect to FIGS. 4 and 5.

[0011] In the embodiment depicted in FIG. 2, the micro camera module 202 is used to focus and capture an object 208 disposed on a side of the hand-held device 100 that is opposite to the side upon which the display 104 is mounted. For example, a user would use the hand-held device 100 to point to an object 208 and then view an image of the object on the display 104. However, the hand-held device 100 is not necessarily restricted to tracking an object disposed on the opposite side of the hand-held device 100 as the display 104. For example, the micro camera module 202 may capture the user of the hand-held device and create an image of the user for video conferencing, e.g., the image is transmitted to a remote display device that is capable of providing video conferencing.

[0012] FIG. 3 depicts the stabilization of an image in accordance with the present invention. The hand-held device 100 is subject to one or more external forces, e.g., a shaking or vibration of a hand holding the hand-held device 100 or other unintended movements of the hand-held device 100, and is moved as shown by arrow 304. This movement causes the position of the image displayed on the display device 104 to change so that for example the desired image is no longer centered on the display 104. To prevent undesired changes in the image, image stabilization is employed.

[0013] The micro camera module 202, is initially located at a first position 302, the lens 204 focuses on an object 208 and the image sensor 206 captures the object. The hand-held device 100 is moved, in a direction 5 shown by arrow 304, such as by an unintended movement or shaking of the hand-held device 100, to a second position 306, in which the position of the micro camera module 202 after this movement is shown with a dotted lines 308. To maintain substantially the same view of the object 208, at least the lens 204 and the image sensor 206 of the micro camera module 202 must also be rotated in the direction shown by arrow 310. Depending upon the movement of the micro-camera module 202, such compensation movement of the micro camera module 202 within the hand-held device 100 may also and/or alternatively comprise a lateral translation of the micro camera module 202.

[0014] FIG. 4 depicts a block diagram of one embodiment of the hand-held device 100 of the present invention. In this embodiment, the hand-held device 100 comprises a micro camera module 202, a motion sensor assembly 402, a controller 404, an actuator assembly 406 and a display 104. The micro camera module 202 has components suitable to implement a miniature-sized camera within a hand-held device 100. For small hand-held devices 100, such as mobile phones, generally there is only sufficient space in the device to house a single lens 204. However, if size is not a constraint, multiple lenses of a lens assembly may be used. The lens 204 may be in a set position so that only objects within a known range are in focus, or its position may be adjustable by an autofocus or manual focus mechanism which moves the lens to focus on an object within view at any range.

[0015] The micro camera module 202 also comprises an image sensor 206 and a camera digital signal processor (C-DSP) 410. The image sensor 206 defines or captures an image of an object 208 and generates an appropriate electrical signal corresponding to the captured image. Examples of the image sensor 206 include, but are not limited to a CCD (charge-coupled device) and a CMOS-based IC (integrated circuit). Such an image sensor 206 is typically approximately 4 x 4 mm in size. The camera digital signal processor 410 generates an electronic signal in response to the image sensor 206 and transmits this signal to the display 104 which displays a visible image of the object.

[0016] The lens 204 typically will have a very short focal length of approximately 2 to 4 mm and a diameter of approximately 1 to 3 mm. The image sensor 206 will typically be approximately 4 x 4 mm in size. These sizes are merely illustrative as different sizes of these elements are possible depending upon the overall size of the hand held device 100 and the desired quality of the image to be displayed.

[0017] The motion sensor assembly 402 senses movement of the hand-held device 100 such as shaking, vibrations and/or rotation of the hand-held device 100.

The motion sensor assembly 402 comprises one or more electronic motion sensors that sense movement of the hand-held device 100. The motion sensor assembly 402 senses movement of the hand-held device 100. The motion sensor assembly 402 comprises one or more motion sensors that preferably sense movement of the hand-held device 100 in at least two, and preferably three, substantially perpendicular directions. Any type of motion sensor may be used, such as MEMS (microelectronic mechanical systems) sensors, electronic motion sensors, micro machined motion sensors, and the like. In general, there are two types of motion sensors, accelerometers which detect and measure linear acceleration, and gyroscopes, which detect and measure angular rotation. It is preferred to use a motion sensor of the gyroscope type which detects and measures rotation because image destabilization is typically caused by movement of a hand holding the hand-held device which movement is substantially rotational.

[0018] The controller 404 controls the image stabilization of the micro camera module 202 by determining a desired movement of the micro camera module 202 to compensate for movement of the hand-held device 100 so as to maintain the view of the object 208. The controller 404 transmits the amount and direction of the desired movement in the form of a control signal to the actuator assembly 406. Memory 408 in the controller 404 stores data structures and any software modules or applications necessary to process the measured actual movement of the hand held device and to ascertain the appropriate compensation movement, as is known in the art.

[0019] The actuator assembly 406 comprises one or more actuators which are positioned in the hand held device to move the micro camera module 202 in accordance with instructions received from the controller 404. Examples of a suitable actuator include a piezo actuator, a MEMS actuator, a shaped memory alloy (SMA) which changes in length in response to an electrical bias, and other types of electro-mechanical actuators. For an image sensor 206 of approximately 4 mm x 4 mm in size, a translation of approximately 20-50 micrometers and/or a rotation of approximately 0.2-1.0 degrees is typically adequate for sufficient image stabilization to compensate for the movement of the hand-held device 100. Exemplary implementations of these embodiments are further depicted and described with respect to FIGS. 6A, 6B, 7A and 7B, which are discussed in detail below.

[0020] FIG. 5 depicts a block diagram of another embodiment of the hand-held device 100 of the present invention. In this embodiment, the hand-held device 100 contains a lens 204 and an image sensor 206 but does not have a camera digital signal processor 410 as part of the micro camera module 202. The motion sensor assembly 402 and the controller 404 operate in substantially the same manner as the previous embodiment described with respect to FIG. 4. The actuator assembly 406 receives a signal from the controller to move the

lens 204 and the image sensor 206 of the micro camera module 202. A digital signal processor 502 generates a signal to cause the display 104 to generate an image of the object. Exemplary implementations of the embodiments of FIG. 5 are further depicted and described with respect to FIGS. 8A, 8B, 9A and 9B, which are discussed in detail below.

[0021] FIGS. 6A and 6B depict a side and a top view, respectively, of a first implementation of the embodiment of FIG. 4. In this implementation, the axis 407 of the lens 204 of the micro camera module 202 is pivoted, tilted or deflected in response to a movement of the hand-held device 100, as shown by the arrows in FIG. 6A. The axis 407 is represented by a line which passes through a center of curvature of the lens 204. The motion sensor assembly 402 and the actuator assembly 406 are secured to a common plane, such as a circuit board 405 disposed within the hand held device 100. The lens 204 is disposed centrally over the micro camera module 202. The actuator assembly 406 comprises four actuators 406R disposed beneath each corner of the micro camera module 202 so as to support the camera module 202 on the circuit board 405. The actuators 406R are selected so that they are capable of compressing and expanding and, when mounted to the circuit board 405, are capable of pivoting the micro camera module 202 relative to the circuit board 405 as shown by the arrows in FIG. 6A. The movement of camera module 202 by the actuators 406R occurs in response to a signal from the controller 404.

[0022] Rather than being placed at the corners of the bottom of camera module 202, the actuators 406R may alternatively be positioned along the bottom edges of the camera module 202 or completely under the camera module. In addition, although four actuators 406R are shown, more or fewer than four actuators may be used. For example, only two actuators 406R are required with one actuator 406R being positioned at one corner of the camera module 202 and the other actuator 406R being positioned at a neighboring corner of the camera module 202. The camera module 202 is then mounted to the circuit board so that the camera module 202 is capable of pivoting upon activation of one or both of the actuators 406R. Such mounting can be accomplished by attaching the camera module 202 to the circuit board 405 at a third point by a resilient or hinged member. Alternatively, the two actuators 406R may be mounted along adjacent edges of the camera module 202.

[0023] The motion sensor assembly 402 comprises an X-direction motion sensor 402X and an Y-direction motion sensor 402Y. These motion sensors 402X and 402Y sense or detect motion or movement of the hand-held device 100 in substantially perpendicular directions and provide the sensed motion information to the controller 404. The controller 404 then uses the received motion information to determine the required adjustment of the position of the micro camera module 202 to compensate for the movement of the hand-held device

100 to stabilize the image being captured by the micro camera module 202.

[0024] FIGS. 7A and 7B depict a side and top view, respectively, of a second implementation of the embodiment of FIG. 4. The implementation shown in FIGS. 7A and 7B is substantially identical to that shown in FIGS. 6A and 6B except that the micro camera module 202 is moved laterally relative to the circuit board 405 as shown by the arrow in FIG. 7A. The actuator assembly 406 illustratively comprises four actuators 406T disposed beneath each side or outer edge of the micro camera module 202. The actuators 406T are configured to provide a translation of the micro camera module 202 in two substantially perpendicular directions which are in a plane substantially perpendicular to the axis of the lens 204. To perform this translation, the actuators 406T are selected and positioned to cause the camera module 202 to move substantially parallel to the plane of the move the micro camera module 202 circuit board 405.

[0025] Although the four actuators 406T are shown as being disposed at corners of the camera module 202, alternatively they may be placed along edges of the camera module 202, or beneath the camera module 202. Additionally, more or fewer than four actuators 406T may be used. For example, only two actuators 406T are required, each being positioned at two adjacent edges or corners of the camera module 202, optionally with a means to stabilize the mounting of the camera module 202 onto the circuit board 405, such as a resilient or sliding member. Alternatively, the two actuators may merely be interposed between the camera module 202 and the circuit board 405.

[0026] In addition, the actuators 406 may be selected, positioned and orientated so that the micro camera module 202 can be moved in the way described with respect to FIGS. 6A and 6B, and also in the way described with respect to FIGS. 7A and 7B, that is, so that the axis of the lens of the micro camera module 202 can both pivot and so that the micro camera module 202 can move in a plane substantially perpendicular to the axis of the lens of the micro camera module 202.

[0027] FIGS. 8A and 8B depict side and top views, respectively, of a first implementation of the embodiment of FIG. 5. This implementation is substantially identical to that shown in FIGS. 6A and 6B except that the camera module 202 does not include a camera digital signal processor. Instead, the signal processor, in this case a digital signal processor 502, is mounted to the circuit board 405.

[0028] FIGS. 9A and 9B depict side and top views, respectively, of a second implementation of the embodiment of FIG. 5. This implementation is substantially identical to that shown in FIGS. 8A and 8B except that, again, the camera module 202 does not include a camera digital signal processor. Instead a digital signal processor 502 mounted to the circuit board 405 is used.

[0029] FIG. 10 depicts a flow chart for implementing a method of the present invention for stabilizing an im-

age obtained with a hand-held device 100 having a camera. The method is activated when a user selects the image stabilization feature by depressing or otherwise selecting a button or sequence of buttons on the keyboard 112, step 1002. An object is focused upon using the lens 204, step 1004. A query checks the motion sensors to determine whether the hand-held device 100 has been moved, step 1006. If there is no movement of the hand-held device 100, the method returns to step 1006 so that, step 1008 is repeated until movement of the hand-held device 100 has been detected. If movement of the hand-held device 100 has been detected, the controller determines or calculates how to actuate the actuators to compensate for the movement of the hand-held device, step 1008. The actuators are then instructed to move the micro camera module 202 (or the lens and image sensor, as appropriate) to compensate for the movement of the hand-held device 100. After step 1010, the method returns to step 1006.

[0030] The image stabilization method applies only if movement of the hand-held device 100 is within a pre-determined threshold distance or angle relative to the viewing frame 208.

[0031] Thus, while there have been shown and described and pointed out fundamental novel features of the present invention as applied to a preferred embodiment thereof, it will be understood that various omissions and substitutions and changes in the form and details of the devices described and illustrated, and in their operation, and of the methods described may be made by those skilled in the art without departing from the spirit of the present invention. For example, it is expressly intended that all combinations of those elements and/or method steps which perform substantially the same function in substantially the same way to achieve the same results are within the scope of the invention. Substitutions of elements from one described embodiment to another are also fully intended and contemplated. It is also to be understood that the drawings are not necessarily drawn to scale but that they are merely conceptual in nature. It is the intention, therefore, to be limited only as indicated by the scope of the claims appended hereto.

Claims

1. A hand-held device for capturing a stabilized image of an object comprising:
an optical lens assembly comprising an optical lens and being capable of providing an image of an object;
an image sensor positioned to receive the image of the object from said lens of said lens assembly, said image sensor generating an electronic signal corresponding to the received image;

- a motion sensor for sensing movement of at least said lens assembly and said image sensor and for generating a movement signal indicative of the movement of at least said lens assembly and said image sensor; 5
an actuator positioned to be capable of moving said lens assembly and said image sensor; and a controller operatively connected to said motion sensor and said actuator so as to receive from said motion sensor the movement signal and in response thereto to transmit a signal to said actuator to cause said lens assembly and said image sensor to move so as to substantially maintain the image of the object by substantially correcting for the sensed movement of said lens assembly and said image sensor.
2. A hand held device as claimed in claim 1, further comprising a digital signal processor operatively connected to said image sensor for processing the electronic signal generated by said image sensor and for generating a processed electronic signal capable of driving a display to display the image. 10
3. A hand held device as claimed in claim 1 or claim 2, further comprising a display operatively connected to said digital signal processor for displaying the image in response to receipt from said digital signal processor of the processed electronic signal. 15
4. A hand held device as claimed in any one of the preceding claims, wherein said optical lens assembly further comprises a means for causing said optical lens to focus on the object. 20
5. A hand held device as claimed in any one of the preceding claims, wherein said lens has an optical axis, and wherein said actuator is positioned and selected so as to be capable of causing said lens assembly and said image sensor to move so as to pivot the optical axis. 25
6. A hand held device as claimed in any one of the preceding claims, wherein said lens has an optical axis, and wherein said actuator is positioned and selected so as to be capable of causing said lens assembly and said image sensor to move in a plane substantially perpendicular to the optical axis of said lens. 30
7. A hand held device as claimed in any one of the preceding claims, wherein said lens has an optical axis, and wherein said actuator is positioned and selected so as to be capable of causing said lens assembly and said image sensor to move so as to pivot the optical axis, and to be capable of causing said lens assembly and said image sensor to move in a plane substantially perpendicular to the optical 35
- axis of said lens.
8. A hand held device as claimed in any one of the preceding claims, wherein said lens assembly and said image sensor comprise a camera module, wherein said actuator is positioned to be capable of moving said camera module, and wherein said motion sensor senses movement of said camera module. 40
9. A hand held device as claimed in any one of the preceding claims, wherein two motion sensors are oriented so as to sense movement of at least said lens assembly and said image sensor in two substantially perpendicular directions. 45
10. A hand held device as claimed in any one of the preceding claims, wherein there are at least two actuators. 50
11. A hand held device as claimed in any one of the preceding claims, wherein there are four actuators. 55
12. A hand held device as claimed in any one of the preceding claim 1, wherein said actuator comprises one of a piezo actuator, a MEMS actuator, and a shaped memory alloy.
13. A hand held device as claimed in any one of the preceding claims, wherein said hand-held device is a mobile phone.
14. A method for stabilizing an image captured of an object by a camera integral with the hand-held device, the camera comprising an optical lens assembly comprising an optical lens and being capable of providing an image of an object, an image sensor positioned to receive the image of the object from the lens of the lens assembly, the image sensor generating an electronic signal corresponding to the received image, the method comprising:
- sensing movement of at least the lens assembly and the image sensor;
- generating a movement signal indicative of the sensed movement of at least the lens assembly and the image sensor; and
- moving the lens assembly and the image sensor in response to the movement signal so as to substantially maintain the image of the object by substantially correcting for the sensed movement of the lens assembly and the image sensor.
15. A method as claimed in claim 14, wherein the lens assembly and the image sensor are moved so as to pivot an optical axis of the lens.

16. A method as claimed in claim 14, wherein the lens assembly and the image sensor are moved in a plane substantially perpendicular to an optical axis of the lens.

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17. A method as claimed in claim 14, wherein the lens assembly and the image sensor are moved so as to pivot an optical axis of the lens and are moved in a plane substantially perpendicular to an optical axis of the lens.

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Fig.1

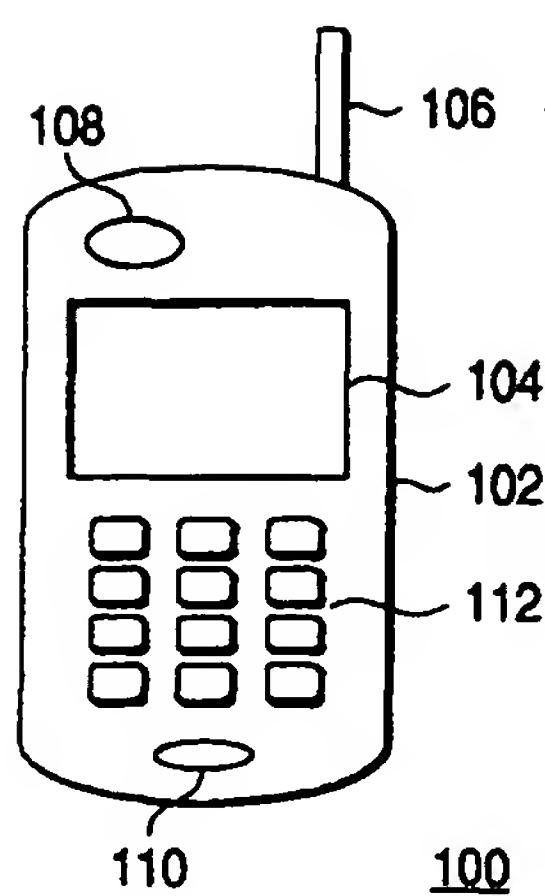


Fig.2

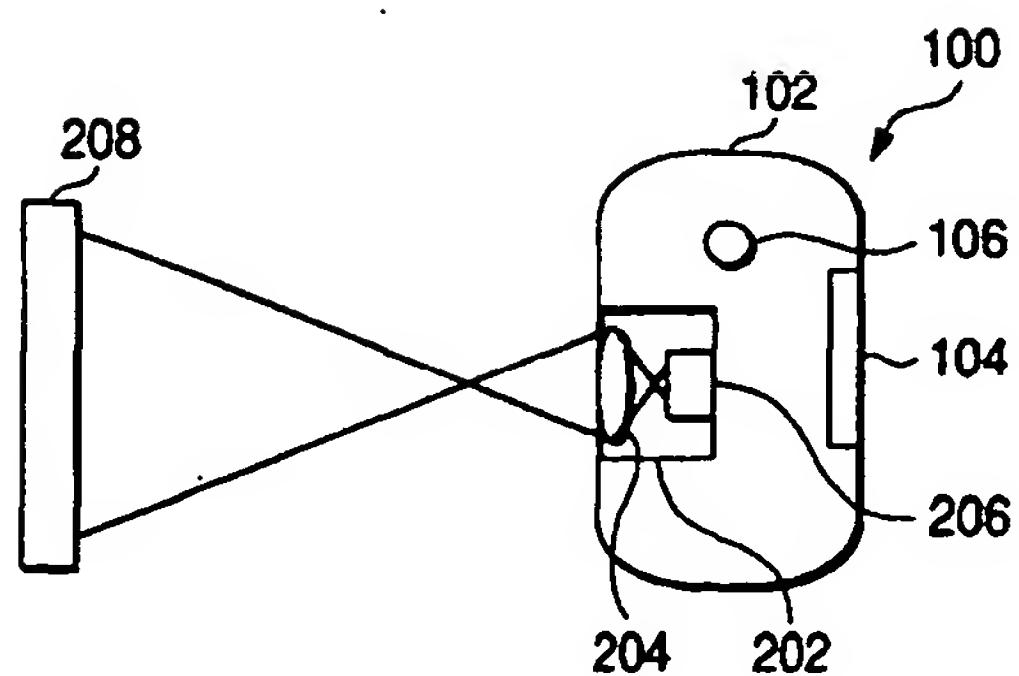


Fig.3

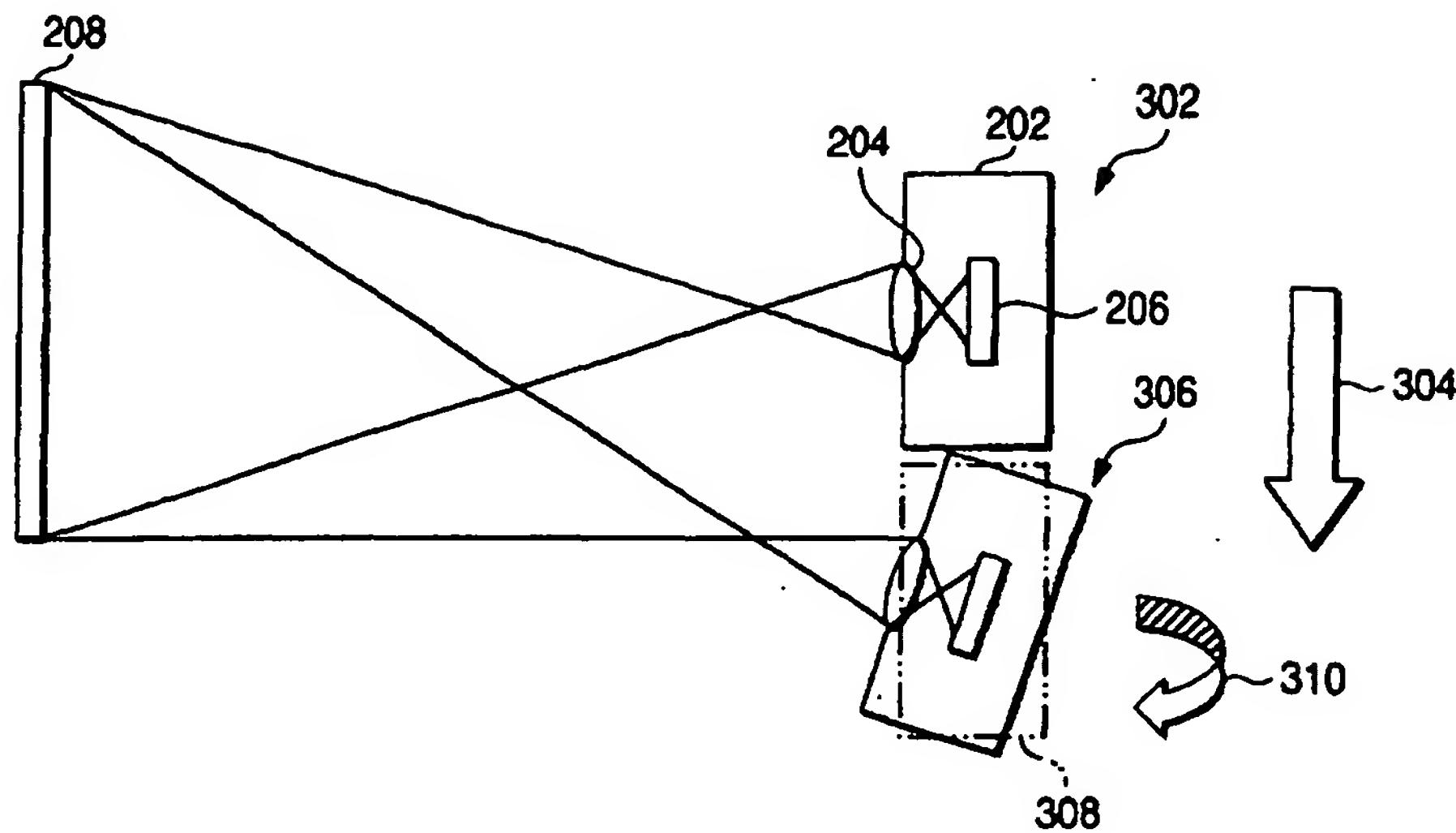


Fig.4

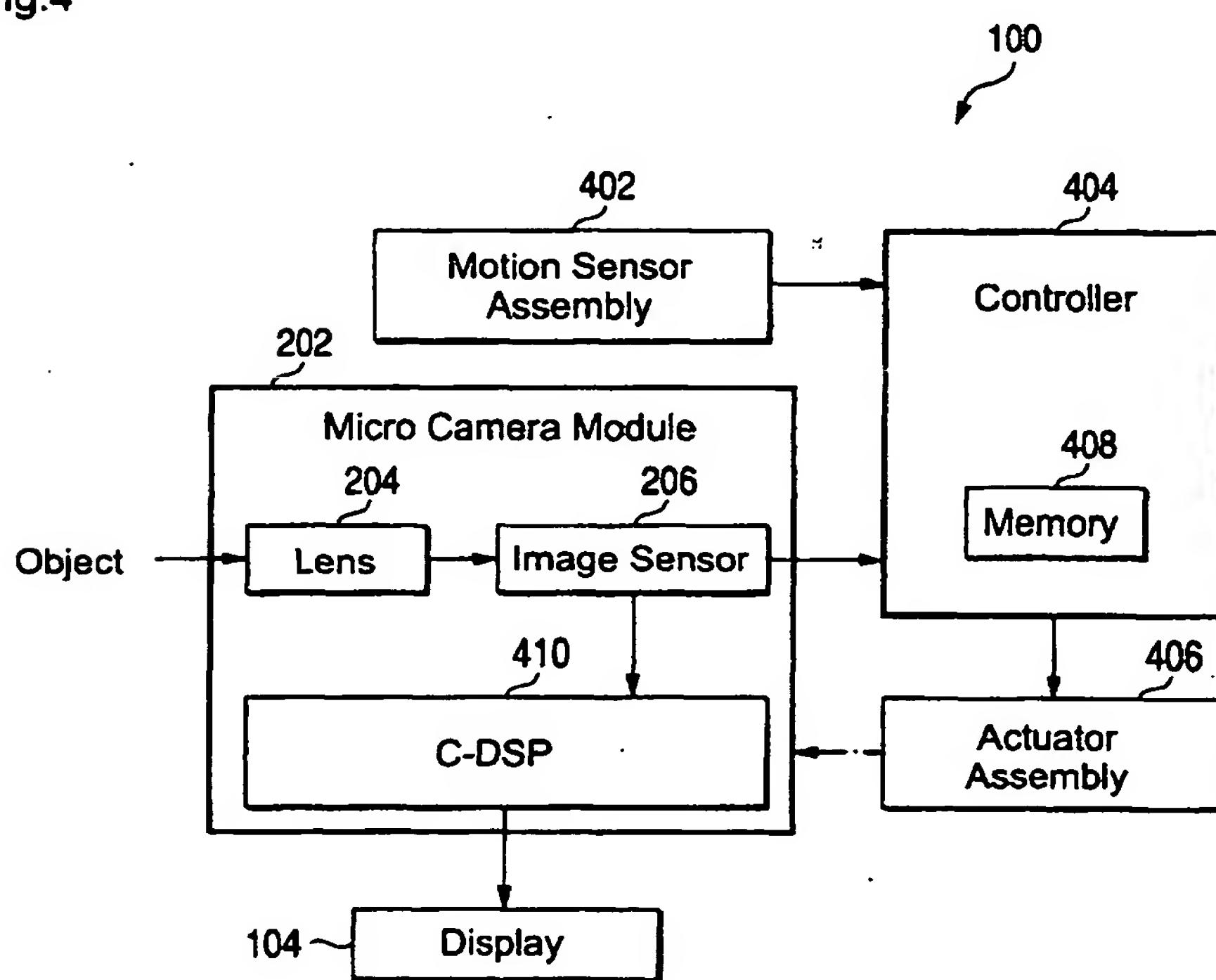


Fig.5

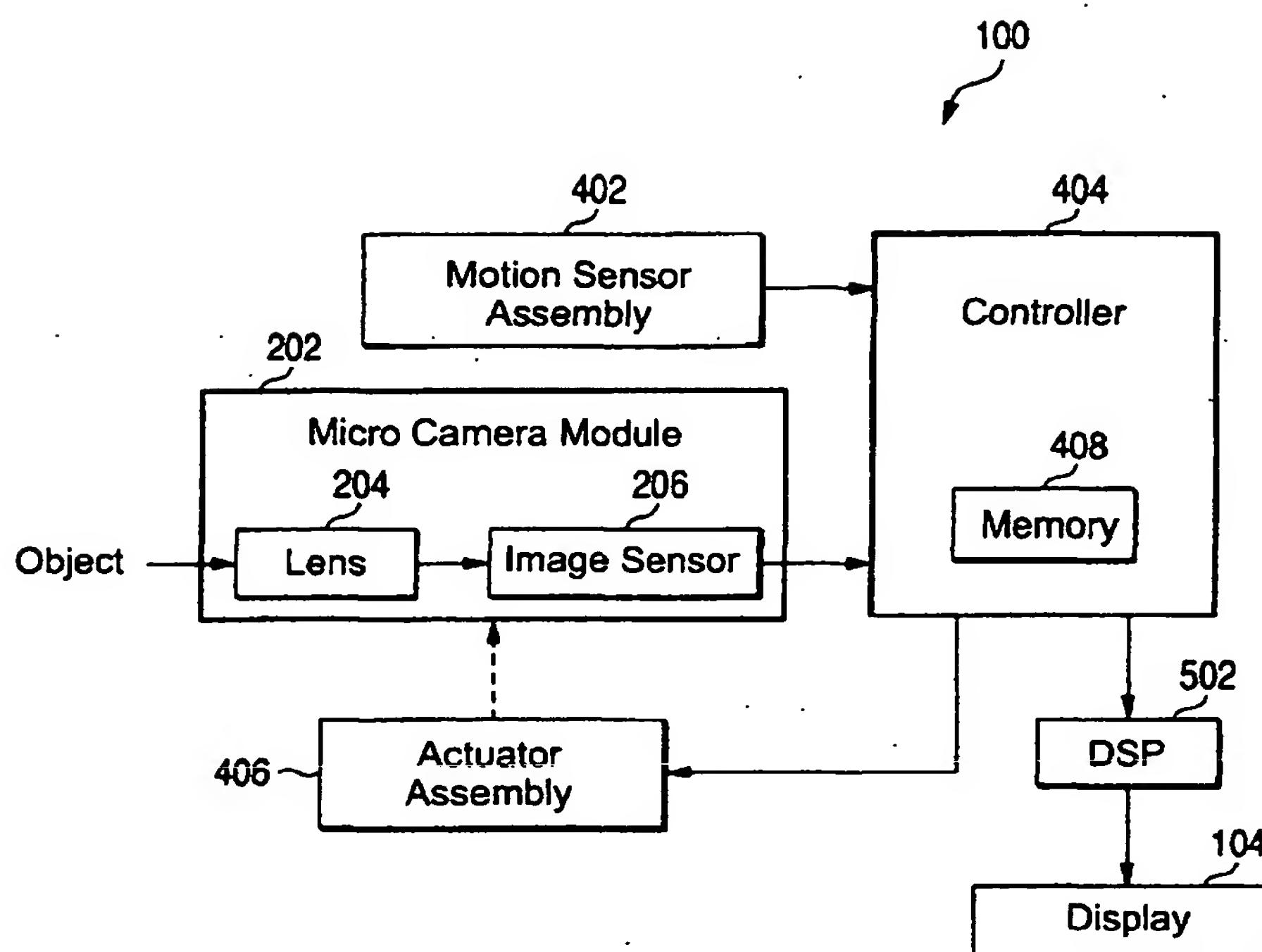


Fig.6A

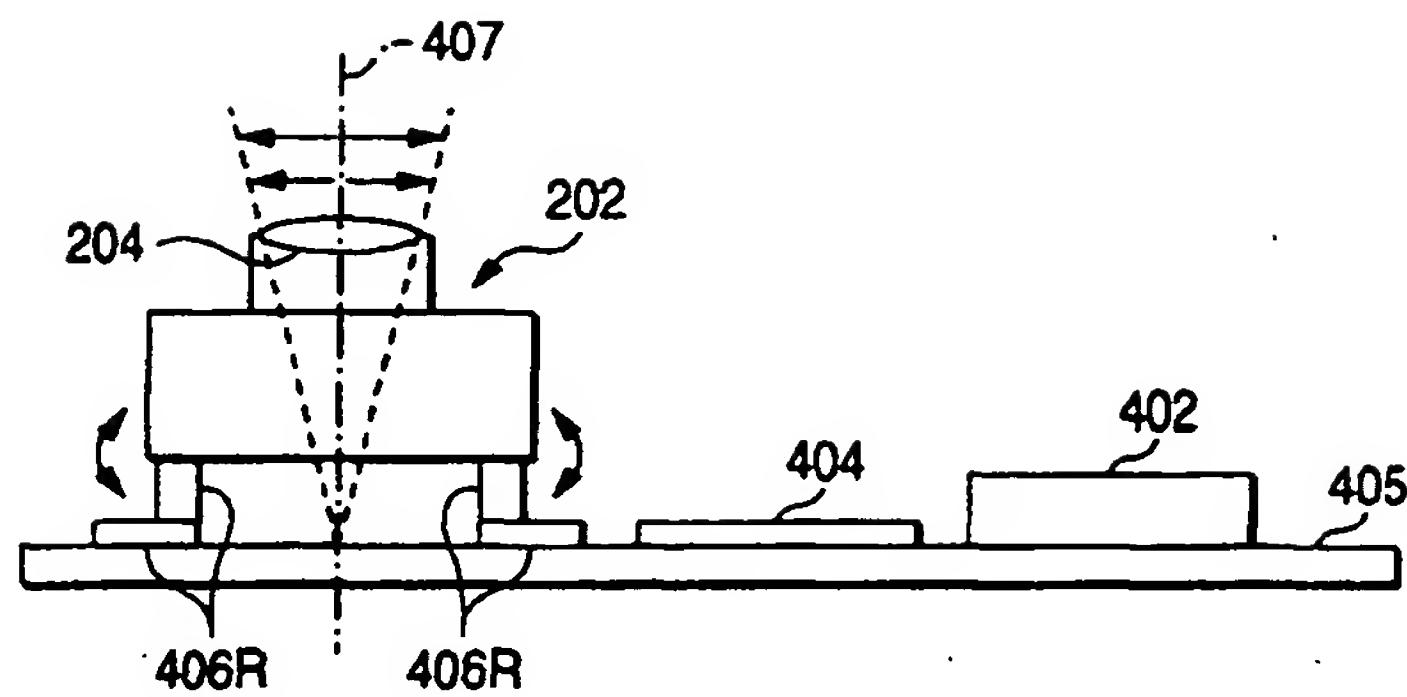


Fig.6B

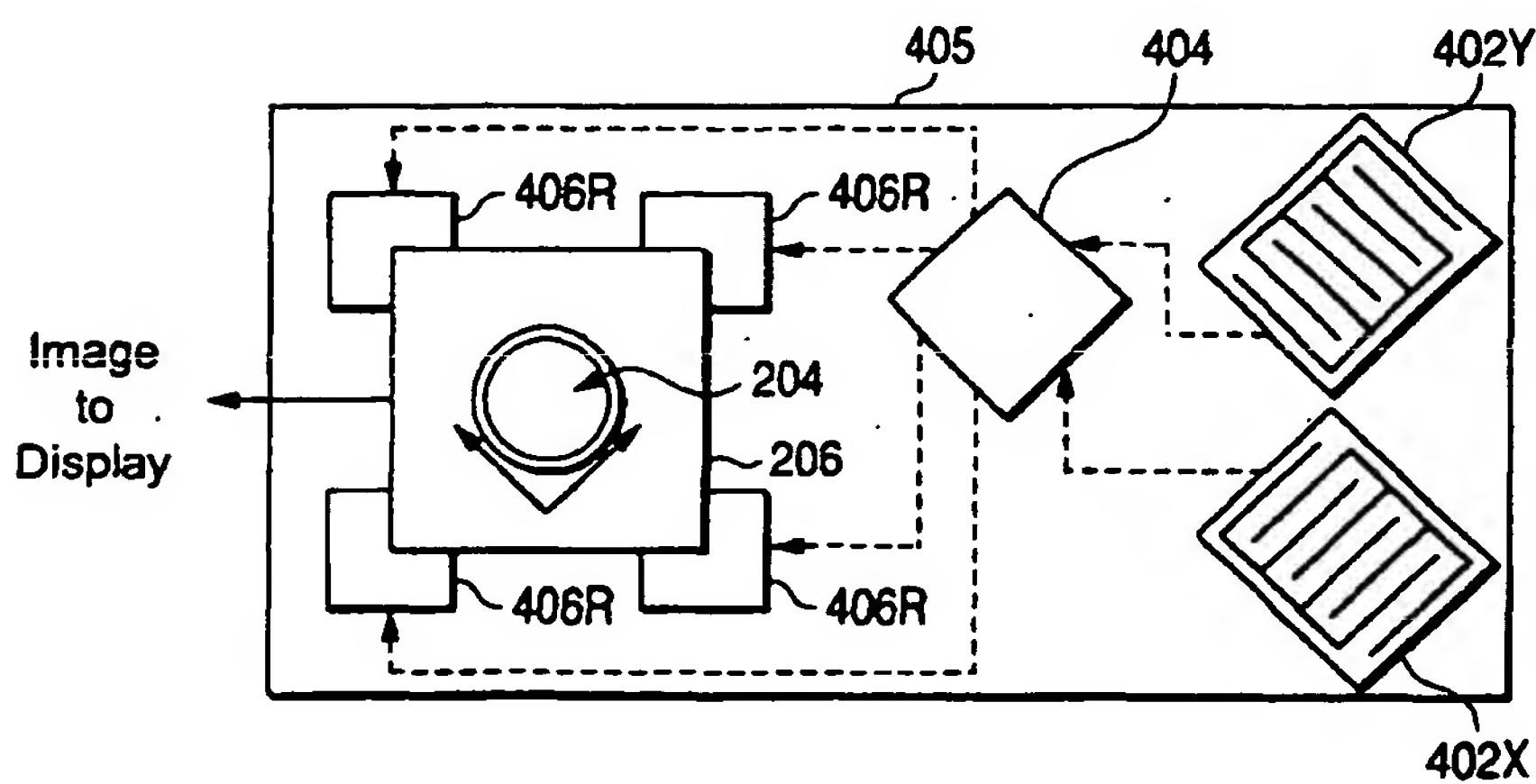


Fig.7A

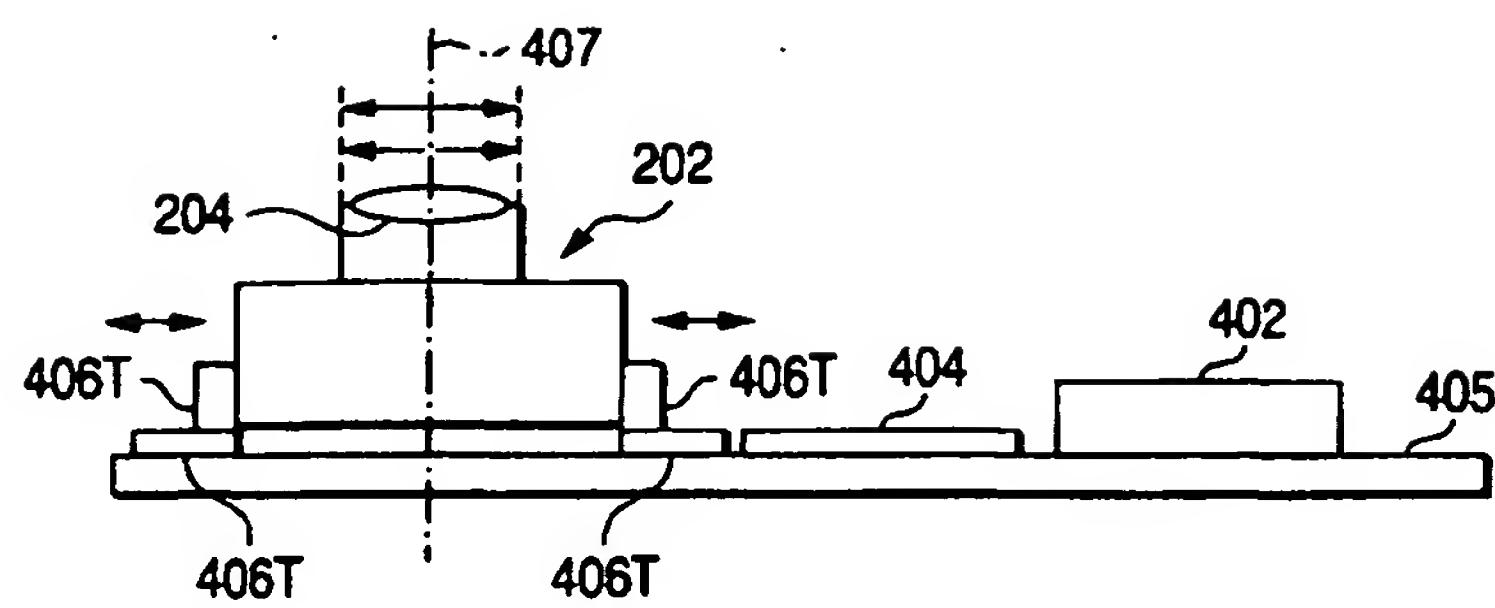


Fig.7B

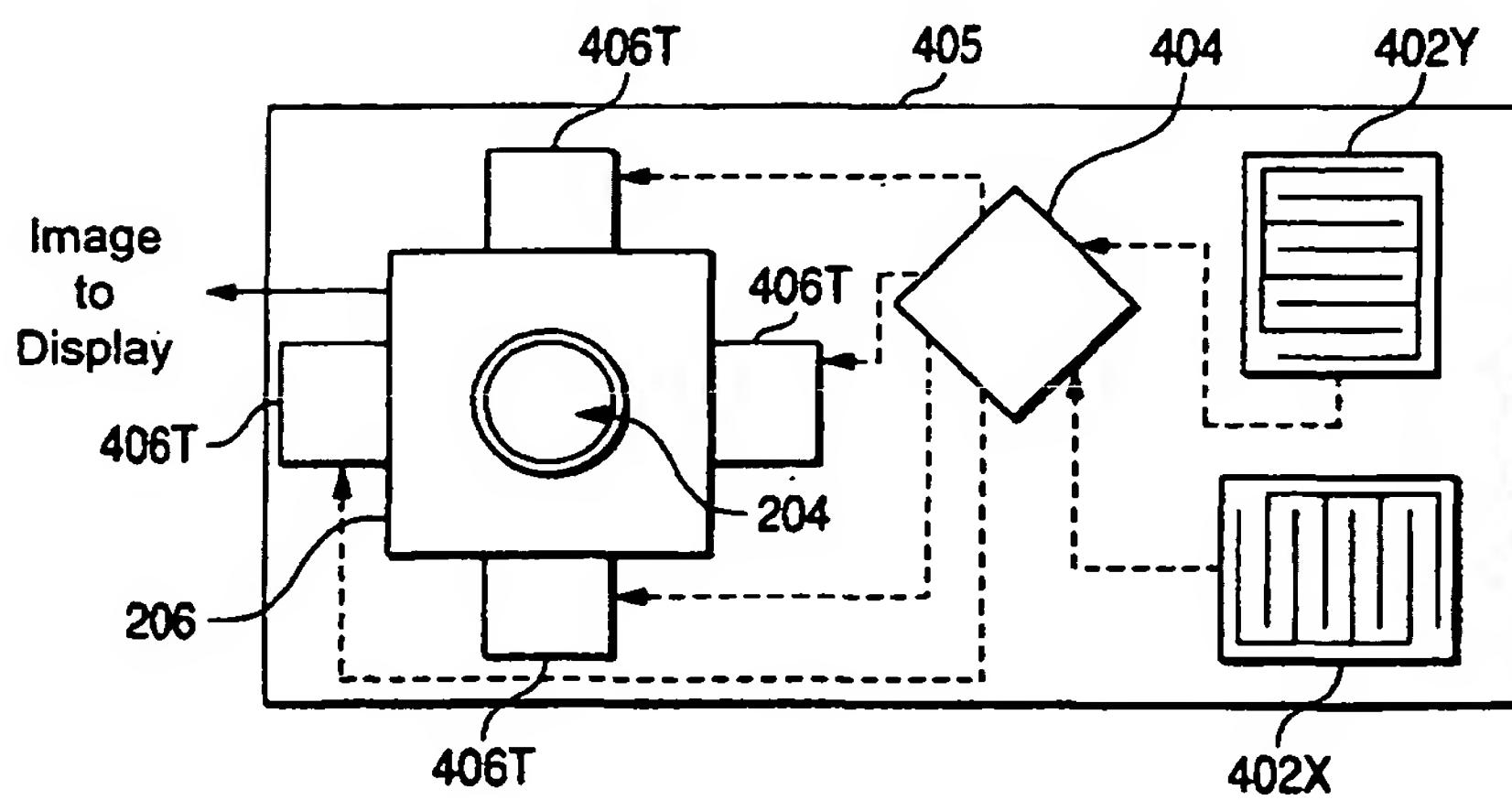


Fig.8A

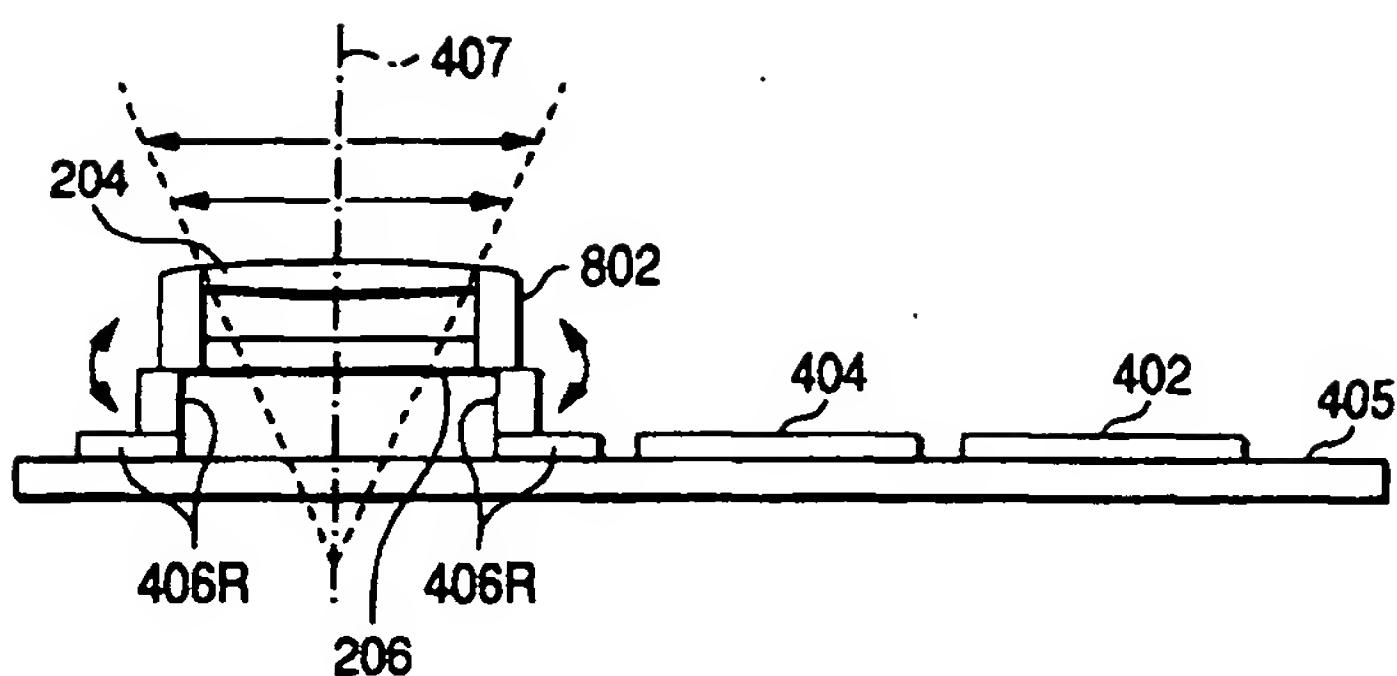


Fig.8B

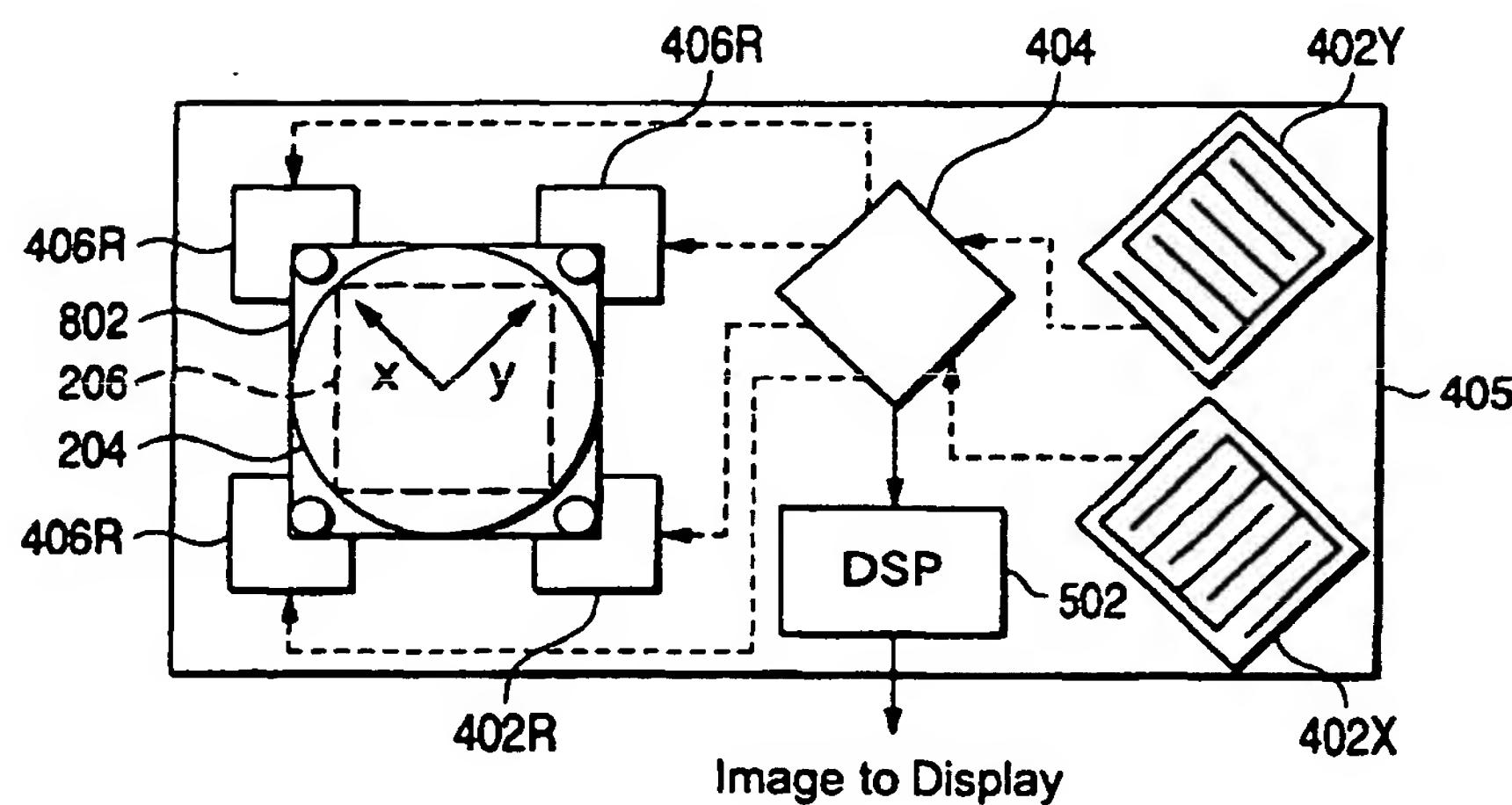


Fig.9A

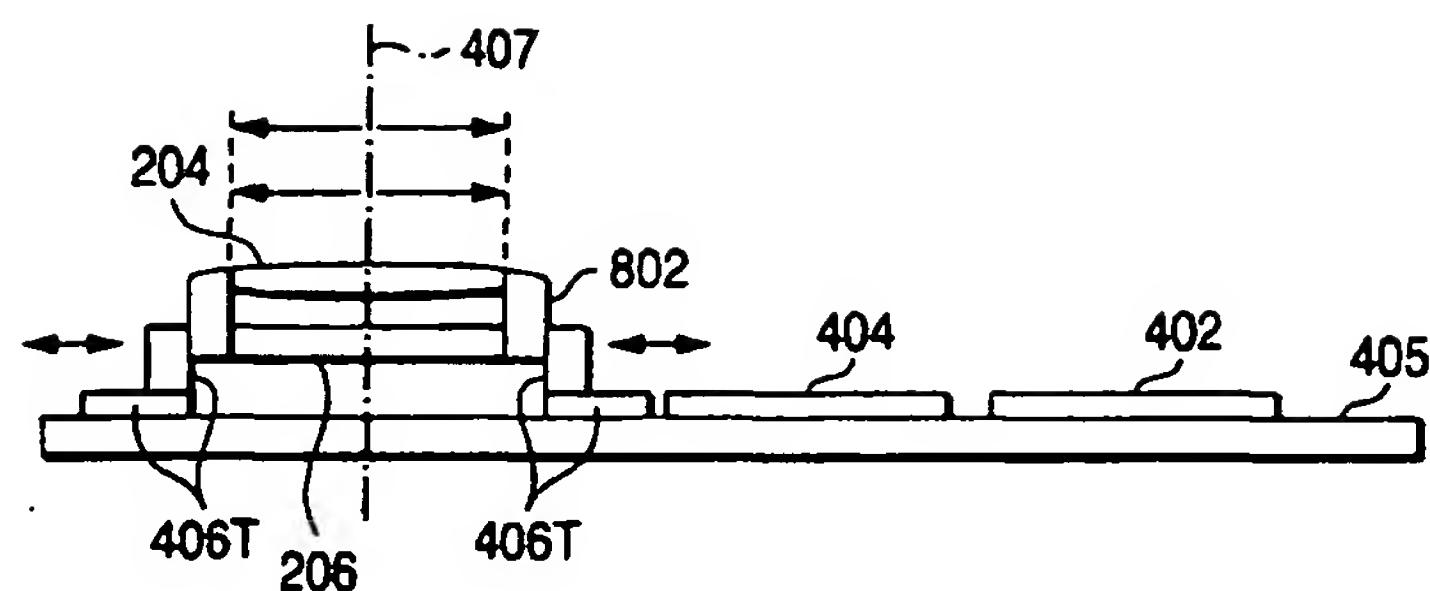


Fig.9B

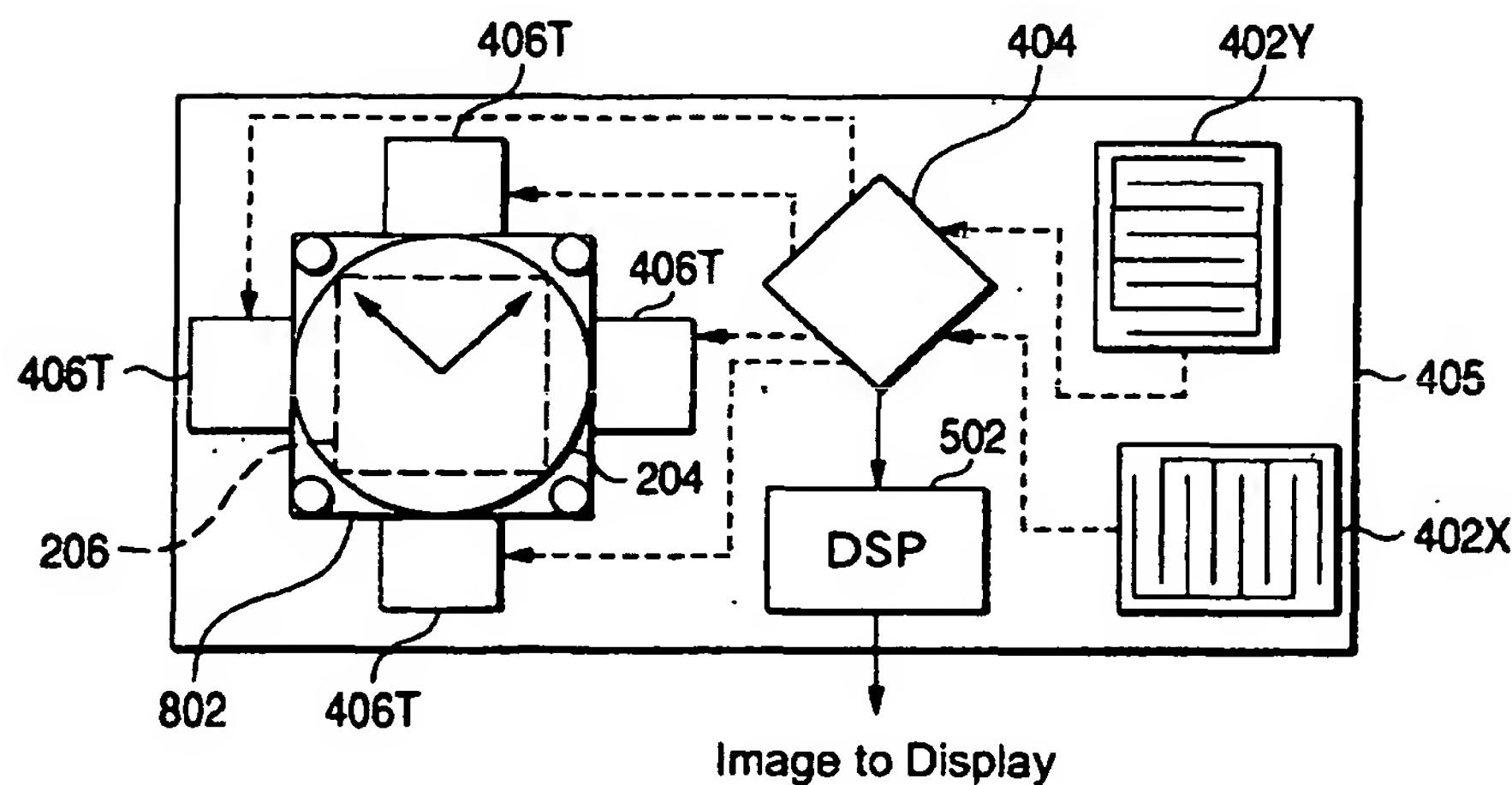
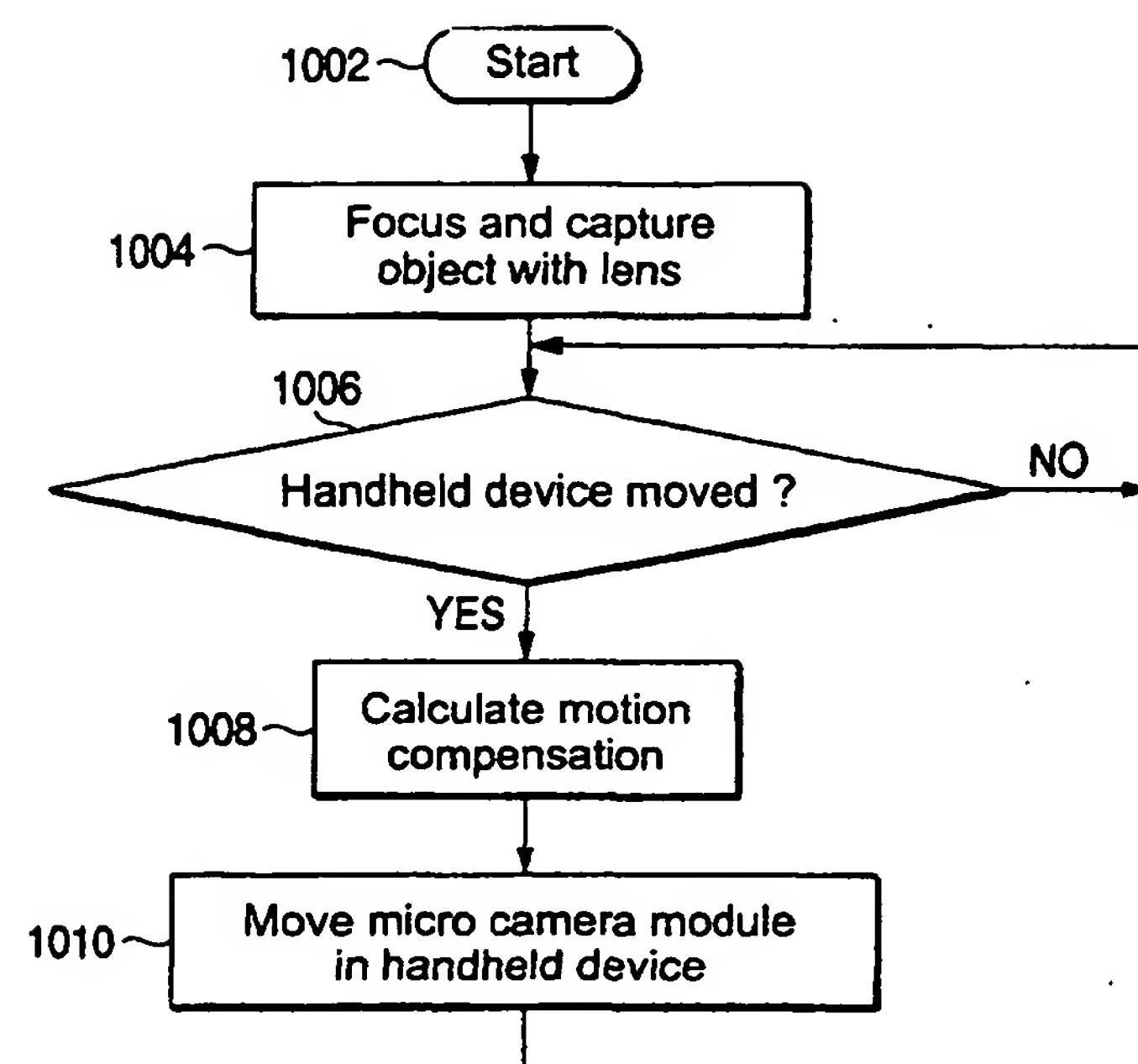


Fig.10





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 25 7143

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 11, 30 September 1998 (1998-09-30) -& JP 10 170971 A (OLYMPUS OPTICAL CO LTD), 26 June 1998 (1998-06-26) * abstract; figure 2 * ---	1,4,5, 8-10,14, 15	H04N5/232
X	US 4 731 669 A (KAJINO JIROU ET AL) 15 March 1988 (1988-03-15) * claims 1,14 * ---	1,4,5, 8-10,14, 15	
X	PATENT ABSTRACTS OF JAPAN vol. 011, no. 099 (E-493), 27 March 1987 (1987-03-27) & JP 61 248681 A (CANON INC), 5 November 1986 (1986-11-05) * abstract * ---	1,14	
X	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 10, 31 August 1998 (1998-08-31) -& JP 10 142646 A (OLYMPUS OPTICAL CO LTD), 29 May 1998 (1998-05-29) * abstract; figure 9 * -----	1,14	<p>TECHNICAL FIELDS SEARCHED (Int.Cl.7)</p> <p>H04N</p>
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	28 February 2003	Wahba, A	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons 8 : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 02 25 7143

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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28-02-2003

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